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GENERALISING THE LAND COVER MAP OF GREAT BRITAIN TO CORINE LAND COVER BY SEMI-AUTOMATED MEANS

Evaluation of semi-automated procedure

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Putting Information To Work

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EXECUTIVE SUMMARY

1. The European Commission (EC) programme 'Co-ordination of Information on the Environment' (CORINE) includes a major project to map the land cover and land use of member states.

2. The CORINE Land Cover map, generally produced in the late 1980's - early 1990's by visual interpretation and manual digitising, shows 44 cover types, in vector format (i.e. as digital map outlines) at 1:100 000 scale, with a minimum mappable unit of 25 ha.

3. The Land Cover map of Great Britain (LCMGB) of 1988-90 gives a raster (i.e. grid-based) map which records cover on 25 m cell size, identifying 25 cover-types, with a minimum mappable unit of 0.125 ha, showing landscape patterns at field-by field scale.

4. This projects aims to generalise the LCMGB to CORINE Land Cover format using a semi-automated generalisation procedure developed in 1994 by ITE.

5. The generalisation procedure has been made operational. It has been adapted to run on ARC/View and made more efficient.

6. Conversion has been completed for all of GB.

7. The preliminary map is currently undergoing quality checks and local interactive correction as necessary.

8. Preliminary outputs for Arable, Pastural, Upland and Marginal landscapes have been evaluated by comparing results from manual interpretation of satellite imagery (as described in the CORINE technical guide) with results produced by the semi-automated generalisation. The overall correspondence achieved between manual and semi-automated procedure is 83 %. This is believed to represent the correspondence of two maps (the CORINE land cover of GB and the manually interpreted map) each with *c.* 90% accuarcy.

1. INTRODUCTION

1.1 The European Environment Agency (EEA) was launched by the European Union (EU) in 1993 with a mandate to co-ordinate and put to strategic use information of relevance to the protection and improvement of Europe's environment. The Agency carries out its tasks in co-operation with a European Information and Observation Network (EIONET). EIONET consists of national networks, organised by the Agency to help it retrieve information, and produce efficient and timely information on Europe's environment. To execute particular tasks, institutions or organisations have been contracted as European Topic Centres (ETC). There are today ETCs for Air Emissions, Air Quality, Catalogue of Data Sources, Inland Waters, Land Cover, Marine & Coastal Environment, Nature Conservation and Soil. The ETC on Land Cover (ETC/LC), led by the Environmental Satellite Data Centre (MDC) in Sweden, was established to provide accurate data on land cover in Europe, corresponding to needs across a wide range of applications.

1.2 A key activity of ETC/LC has been the completion of a European-wide inventory of land cover in 44 classes. This takes the form of a digital cartographic product, at a scale of 1:100 000. The inventory has been compiled, mostly in the late 1980's - early 1990's, using methods developed within the CORINE (Co-ordinating Information on the European Environment) experimental programme, undertaken by the Environment Directorate (DGXI) of the European Commission between 1980 and 1985. A major task of ETC/LC has been to develop and complete the Land Cover database begun within the CORINE programme. Today the CORINE land cover data base is operationally available for the greater part of the 3.5 million km² covered by the European Union and progress is being made, through the PHARE programme, in the production of maps to CORINE standards for the former Soviet Union states.

1.3 The land cover of Great Britain was mapped in detail by the Institute of Terrestrial Ecology using remotely-sensed data (Fuller *et al.* 1994a). The British land cover map differs from CORINE in several respects, including its spatial resolution, the land cover classes mapped and the method of production.

1.4 The CORINE Land Cover map has generally been produced by visual interpretation of hard copy satellite images followed by manual digitising to give computer maps which show 44 cover types, as digital map outlines, in vector format at 1:100 000 scale, with minimum mappable units of 25 ha. The Land Cover Map of Great Britain (LCMGB) is a raster or grid-based product which records 25 cover-types, on 25 m grid, with minimum mappable units of 0.125 ha, showing landscape patterns at the field-by-field scale.

1.5 A pilot study successfully demonstrated semi-automated procedures to convert the LCMGB to CORINE specifications. These procedures involve generalisation from the 25 m resolution, reassignment of LCMGB classes to the CORINE categories, generation of CORINE mosaic classes from heterogeneous regions, and use of knowledge-based operations to add relevant land use information (Fuller & Brown 1994, 1996).

1.6 It was concluded that there would be significant financial benefits of automated conversion of the LCMGB to CORINE format, a process which was estimated to cost about 15% the price of new CORINE mapping of Britain. Conversion would ensure that CORINE land cover data for Britain were calibrated against the existing National map and against proven ground reference data available from Countryside Survey 1990. The approach would

also ensure that information on CORINE land cover in Britain is entirely consistent with the national data-set and with the large number of uses to which these data have already been put.

1.7 This project therefore aims at converting the existing Land Cover Map of Great Britain to CORINE Land Cover format by semi-automated means. The work is jointly funded by the Directorate-General XVI for Regional Policy and Cohesion (DGXVI) of the European Commission (EC) and the UK Department of Environment and Transport (DETR), . The work is being carried out by the UK Institute of Terrestrial Ecology (ITE), .

1.8 The generalisation procedures and CORINE outputs are being evaluated by the Technical Unit of the ETC/LC represented by Cristina Seabra of CNIG, Portugal.

1.9 An Advisory Group with a flexible membership to meet specific advisory needs which prevail at any one time, oversees the production. The business of the Advisory Group is a two way process, mainly for ITE to assure deliverables are on time and of the quality required; and to advise or seek advice if and when problems arise. The projects advisory group members are:

Dr Andrew Stott	Department of the Environment, Transport and Regions
Dr Michael Alb<s	Commission of the European Communities, DGXVI
Dr Chris Steenmans	European Environment Agency
Dr Vanda Perdigvo	Commission of the European Communities, Joint Research Centre
Dr Stuart Gardner	Scottish Office

2. EVALUATION AND CALIBRATION

The standard procedure developed to validate the CORINE Land Cover map is described in the CORINE technical guide. The method uses extensive field surveying and aerial photography to check the accuracy of the CORINE Land Cover map product. The Land Cover Map of Great Britain is based on satellite imagery dated between 1989 and 1990. There is no substantial set of aerial photography available for that period and the size (1 km^2) of the 508 Countryside Survey field samples collected in 1990 is inadequate for a validation exercise as described in the technical guide.
To assess the differences between automated and manual outputs, areas were plotted at 1:1 000 000 scale onto A3 size paper giving study areas of 43 km x 29 km. The sites were chosen to cover the four main landscapes in GB (i.e. Arable, Pastural, Upland and Marginal landscapes - see Barr *et al.*, 1993). Whereas any one site may comprise predominantly one landscape, there is some intermixing within the rectangular study areas and test site results were disaggregated in order to analyse the results by landscape type and then provide appropriate weighting according to the national extents of the landscapes. Table 1 lists the percentage of land covered by each of the four landscape types in GB. Together, the validation areas contain a variety of CORINE land-use and land-cover classes.

Table 1. Percentage of land covered by each of the four landscape types in GB

Landscape type	% coverage
Arable land	34
Pastural land	29
Upland	21
Marginal land	16

Once complete, including manual corrections to automated outputs, the CORINE map of GB will be further evaluated by:

(i) comparing the class statistics of the LCMGB with these of the CORINE Land Cover map,
(ii) evaluating the changes in class statistics caused from one generalisation step to the other,

3. ASSESSING THE DIFFERENCES BETWEEN AUTOMATED AND MANUAL OUTPUT FOR EACH TEST SITE

Interpretation of CORINE classes was based on the same Landsat TM images which were used in the original per-pixel classifications. The interpreter was a member of the original LCMGB production team. This meant that he had good familiarity with the images, including the summer-winter composites and familiarity with the LCMGB classes and their visual interpretation (through training the image classifier). However, the interpreter had not practised long term operational mapping of CORINE cover; he was not fully familiar with all the test sites; he had difficulties in the interpretation of borderline classes, in the exact delineation of polygons, in the operation of the 25 ha minimum mappable unit rule and in the visual interpretation of mosaic classes. The manual output is not a 'ground truth' dataset and probably incorporates the usual 10-15% error that would be normal for any CORINE interpretation. Its production is intended to identify substantial discrepancies in the automated procedure rather than to measure the 'absolute accuracy' of its output product.

The CORINE manual interpretations were compared with the CORINE outputs from the semi-automated procedure. Comparisons were carried out, both visually (i.e. qualitatively) and through correspondence tables (i.e. quantitatively).

3.1 Test site: Arable landscape (Cambridgeshire) - (Figure 1, Table 2)

The Cambridgeshire test site consists almost entirely of arable landscape with small pockets of pastural landscape. The visual quality of the automated output is excellent, closely matching the manual version (Figure 1). It maintains the more complex outlines of the original input, but this detail is not excessive and does not merit further generalisation. Indeed, it could be argued that the manual output oversimplifies outlines. There is no need to remove detail, just for the sake of it.

The correspondence matrix appears in Table 2. It shows that overall the correspondence for test site is 875 per thousand pixels, a good result unlikely to be exceeded. This is because, in recording this correspondence, it should be recognised that deficiencies were noted in both the manual and automated product. The manual output includes a small number of polygons that fall below the 25 ha minimum unit. They represent 0.8% of the total area mapped. Also, some

polygons marginally larger than 25 ha were accidentally omitted. The manual recording method completely overlooked the presence of *1.4.1 Green urban areas* despite their being commonplace in Cambridge and Huntingdon (1.9 % of the map area according to automated results); manual recording also failed to identify the mosaic habitats: *2.4.2 Complex cultivation patterns, 2.4.3 Agriculture with natural areas* and *3.1.3 Mixed forest* which, with the benefit of hindsight, should have been considered (and which totalled 11.7 λ according to automated methods). The exact position of boundaries is inevitably questionable and the generalisation was, of necessity, subjective in operation. The manual procedure also involved several stages: hard copy output with potential distortion of paper prints, drawing with likely discrepancies in outlines, and digitising, all of which added to those discrepancies. Registration and, rubber-sheeting, carried out to achieve full registration to UTM and accommodate geometric discrepancies in traced film outlines, did eliminate some misplacements but definitely not all non-systematic errors introduced during the manual procedure (Figures 2 and 3). This is not to argue that manual procedures were less accurate than automated one: simply to point out that this manual exercise was subject to all the same potential errors which are recorded in other countries' manual CORINE mapping. If manual/visual interpretation achieved 95% accuracy, then a correspondence of 87.5% would imply a possible accuracy of 92% on the part of the automated procedure.

The indicated level of accuracy exceeds normal expectations and gives considerable faith in the automated procedures. A closer look at class-level correspondence highlights the specific differences. However, it must be recognised that rarer classes (at least those which are rare in this study area) cannot be adequately assessed, as minor boundary differences for few smaller parcels may cause major quantitative differences; also the chance inclusion/exclusion of just a single polygon can cause a large percentage difference.

The manual method has been more generous in its inclusion of pasture and amenity grassland around villages as part of the *discontinuous urban* (1.1.2). More pixels have been assigned by the automated method to *continuous urban* (1.1.1) and less to *discontinuous urban* (1.1.2). The land use classes (1.2.* to 1.4.*) were captured manually in both methods. The two methods give very similar results except that the manual procedure overlooked the need to record 1.4.1. and scored a lower land use for s*ports and leisure* (1.4.2). The manual procedure generalised, not necessarily correctly, more of the *pasture* (2.3.1) out of the classification, increasing the arable coverage. The dissected patterns of *broad-leaved* and c*oniferous* forests have led to mismatches caused by minor geometric shifts between the maps. No *mixed forest* (3.1.3) areas were identified by the manual interpretation: an oversight. No *Moor/heath* (3.3.2) was recorded by manual interpretation. A very small coverage 0.08% was derived from automated conversion, which is in fact correct. The manual interpretation missed a significant area of long-term set-aside causing confusion between *arable* (2.1.1) and *natural grasslands* (3.2.1). The manual method recorded more *Water bodies* (5.1.2) by aggregating smaller lakes <25 ha into larger ones >25 ha.

3.2 Test site: Pastural landscape (Devon) - (Figure 4, Table 3)

The Devon test site is exclusively made up of pastural landscape. Visual comparison shows a good match between the two products with a similar overall distribution pattern of the cover types present. The overall correspondence achieved between the two methods for the pastural landscape site is 863 pixels per thousand (Figure 4).

This test site is dominated by *pastures* (2.3.1), many small areas of *broadleaved woodland* (3.1.1), and a single very large *mineral extraction* site (1.3.1). It also shows long stretches of

coastline with *intertidal flats* (4.2.3) and *estuaries* (5.2.2). There are few fields of arable crops and these are generally found as single fields surrounded by fields of pasture.

Table 3 shows that the main discrepancies between the manual and semi-automated method are caused by mismatches between *pasture* (2.3.1) and *arable* (2.1.1), *broadleaved woodland* (3.1.1), *natural grassland* (3.2.1) or *mixed cultivation patterns* (2.4.2). In this landscape the size of the arable areas is often near the 25 ha limit. As a result the manual interpretation sometimes failed to identify arable areas that were marginally larger than the 25 ha limit, whilst in other cases arable areas which were marginally smaller than the 25 ha were included. The confusion between *pasture* and *broadleaved woodland* is caused by the same problem. The confusion between pasture and natural grassland simply reflects the enormous difficulty in defining absolute boundaries, based on spectral data, in a continuum of grassland management regimes.

3.3 Test site: Marginal landscape (west Scotland) - (Figure 5, Table 4)

The test site contains areas of marginal, pastural and upland landscape. When assessed visually, the CORINE maps from semi-automated and manual product (Figure 5) show a good match across the area. The percentage correspondence achieved for the test area is 836 per thousand (Table 4).

The test site of western Scotland contained few CORINE 1.*.* classes that required manual digitising (classes 1.1.1 and 1.1.2 are identified automatically). For correct identification of the CORINE classes 3.1.1 (*Coniferous woodland*) and 3.1.2 (*Broadleaved woodland*), manual digitising was necessary to ensure the inclusion of 'recently logged areas', which on the LCMGB are identified as bare. The test area contains a much larger proportion of semi-natural cover classes, such as *natural grasslands* (3.2.1), *moors and heaths* (3.2.2), *transitional wood* (3.2.4) and *peat bogs* (4.1.2). There are also a large number of small and large lakes present.

From Table 4, it is clear that the main differences between the manual and semi-automated methods are caused by the mismatches between boundaries of *natural grasslands* and *moors and heath*. The mismatch caused a loss of *c*. 10% correspondence. For interpreters, the identification of boundaries between natural vegetation types is a major challenge as the transition between natural vegetation types is usually gradual, resulting in fuzzy boundaries. The boundary identified by the semi-automated method is based on a set of rules which interrogate the underlying land cover class of the LCMGB and the cover composition of each polygon > 25 ha. Although, in this case, neither of the two methods consistently produces the 'correct' answer, the semi-automated approach has the advantage of being objective in the way it identifies boundaries between natural vegetation types. The many lochs in the landscape were successfully generalised by the semi-automated procedure.

3.4 Test site: Marginal Landscape (Wales) - (Figure 6, Table 5)

The Welsh test site is a mosaic of marginal, pastural and arable landscapes and is very different from the test area in western Scotland. The Welsh area has steep and narrow built-up valleys with coal mines (*mineral extraction sites*: 1.3.1) and slag heaps (*dump sites*: 1.3.2), some of which are still in operation, others of which are abandoned. The hill-tops and slopes show an intricate pattern of heather moor, semi-natural grasslands and improved pastures with small pockets of woodland and smaller copses.

The general patterns of CORINE classes have been picked up by both methods (Figure 6). Visual examination of the resulting maps reveals one main difference however: the manually digitised CORINE classes, especially the *mineral extraction sites* (1.3.1), vary from the outlines (also manually digitised) of the semi-automated method. The manual digitising of these land use classes was carried out independently (i.e. by different people) for each of the methods. The different results follow from the fact that neither interpreter is familiar with the area, that the spectral signature alone is inadequate for interpretation, that there are no external data which consistently identify the location and extent of these land use features (which anyway are dynamic, soon rendering OS map data out of date). The pattern of *mineral extraction sites* represents two interpreters' best efforts at delineation. Differences are probably attributable to equal levels of mis-interpretation on the manual stage of semi-automated mapping and on the independent manual output.

The correspondence calculated for the test area of Wales is 650 per thousand (Table 5). The complicated nature of the landscape with the narrow valleys and the intricate mixture of natural vegetation types are the main factors for the low correspondence value. In this area, many polygons are thin slivers so that a minor spatial shift between the two maps (manual and semi-automated) would result in low correspondence for these polygons. Moreover, many polygons were near the 25 ha size limit and were wrongly excluded or included by the manual interpreter. Also, in natural areas, as for the west Scotland area, the identification of boundaries between natural classes was very subjective.

3.5 Test site: Upland landscape (east Scotland) - (Figure 7 , Table 6)

The test site is mainly upland landscape. Unlike the marginal test site of west Scotland, it contains much fewer cover classes and the spatial distribution of classes is less intricate and complex. The semi-natural class *moors and heaths* (3.2.2) dominates the landscape covering around 80% of the test area. The remaining 20% of the test area is mainly covered by large blocks of *conifer woodlands* (3.1.2), patches of *natural grasslands* (3.2.1) and *bare rock* (3.3.2). The area contains no 1.*.* classes.

The manual and semi-automated output compare well visually (Figure 7), although the manual interpretation appears to have simplified boundaries and polygons to a greater extent than in the previously discussed test sites. The overall correspondence for the test site is 911 pixels per thousand. The main difference between the two results is caused by mismatches between *natural grasslands* and *moors and heath* (Table 6). Similar to the marginal landscape of west Scotland, the manual identification of boundaries between natural vegetation types proved difficult in the upland test site. There are mismatches between *bare rock* and *moors and heath*. The tendency for the manual interpretation to generalise more (perhaps over-generalise) appears to have created most of these discrepancies. The inclusion of polygons which are marginally smaller than 25 ha and exclusion of polygons which are marginally larger than 25 ha have also decreased the correspondence results to some extent.

4. ASSESSING THE OVERALL DIFFERENCES BETWEEN AUTOMATED AND MANUAL OUTPUT

As has been noted, the selected test areas, especially the ones representing the marginal landscape, include a proportion of landscape types other than the one it was aimed to represent. This has to be taken into account when calculating the overall correspondence results per landscape, since the percentage of land covered by each of the four landscape types in GB is different for each landscape type (Table 1). The ITE Land Classification, which uses combinations of environmental data (such as geology, climate and topography) to allocate land to one of 32 land classes (Bunce *et al*. 1996), was used to create a 1 km grid map showing the areas of GB where arable, pastural, upland, and marginal landscapes dominate (Figure 8). This map was combined with the test sites to identify the areas/pixels belonging to each of the four landscape types (Figures 8 and 9). Correspondence matrices were then produced for each landscape type using the pixels from all test sites which represent that particular landscape (Tables 7, 8, 9 and 10). Table 11 compares the correspondence results found for the five test sites with the results achieved after assigning the test site pixels to the four landscape types.

Table 11 The correspondence results, total number of polygons and pixels for the five test sites and the results found after assigning the test site pixels to the four landscape types.

Test site	Corresp. (pixels/1000)	Total n^o polygons	Total n^o pixels (x 10^3)	Landscape type	Corresp. (pixels/1000)	Total n^o pixels (x 10^3)
Arable, Cambridgeshire	875	322	1224000	Arable	863	1490375
Pastural, Devon	863	236	1201635	Pastural	807	1712610
Upland, east Scotland	911	77	1200884	Upland	890	1635504
Marginal, west Scotland	836	278	1200884	Marginal	714	1192451
Marginal, Wales	650	421	1229936			

The results for the landscape types show a reduction in correspondence ranging from 10 to 60 pixels/1000. The reduction in correspondence is particularly high for the pastural landscape (60 pixels/1000). The pastural landscape is also the landscape type to which the highest proportion of pixels from the two marginal test sites was re-assigned (*c.* 5 x 10^8 pixels). Moreover, most of these re-assigned pixels originate from the marginal test site of Wales (Figure 9) which contains many long thin polygons. The lower correspondence values achieved for these thin polygons has resulted in the lowering of the overall correspondence of the pastural landscape.

An overall correspondence matrix was calculated from the correspondence matrices for the four landscape types by weighting their contribution according to national coverage as follows:

$$C_{GB} = P_a C_a + P_p C_p + P_u C_u + P_m C_m$$

where P_* is the proportion of land covered by landscape * and C_* is the correspondence matrix of landscape *. C_{GB} is the overall correspondence. The resulting matrix is shown in Table 12.

The LCMGB is estimated to be 80%-85% accurate. Supposing (for the moment) that CORINE from manual interpretation were to have had an accuracy of say 90%-100%, and that the semi-automated generalisation procedure perfectly mimics the manual generalisation

process, we would expect an overall percentage correspondence to be 72%-85%. The overall correspondence achieved is 83% (833 pixels per thousand). Though it is 2 % lower than the target of 85%, the value achieved is still within the expected margins of 72-85%. There are several factors which affect the correspondence results:

- The accuracy of the LCMGB will affect the accuracy of its generalised product. Although the overall accuracy of the LCMGB is 80-85 % there are regional variations. For example, the classification results in Wales are known to be lower than the achieved average due to its complex landscape and the inferior quality of the TM imagery used for the classification (Fuller *et al.* 1994b).
- The accuracy of the manual interpretation also varied between test sites as the interpreter had varying local knowledge of the area. Human error cannot be totally eliminated and the proposed 90% to 100% accuracy for a manual interpretation are very optimistic estimations (the upper figure an impossibility).
- The presence of many long thin polygons tend to reduce correspondence results where there are spatial shifts between the two products.
- The inherent difference between the manual and semi-automated approaches have also added to differences in the resulting outputs. Where the manual interpretation heavily relies on well trained and experienced interpreters to reduce the level of subjectivity and exploits the advantage of the interpreters' ability to recognise patterns and textures, the semi-automated procedure achieves consistency through objective sets of rules. For example, the manual identification of CORINE classes which consisted of a mixture of land cover (e.g. *mixed cultivation patterns*: 2.4.2; a*griculture with natural areas*: 2.4.3) proved to be quite difficult while, for the automated procedure, it was just a question of applying the pre-defined rules based directly on the conditions demanded by CORINE standards. The fact that 12% of polygons identified by manual interpretation were smaller than 25 ha is indicative of one problem. Though the < 25 ha inclusions only represent a total 0.04 pixels/1000, they most commonly affected the rarer features in the landscape with a greater proportional impact on their coverage. It is not so clear how many polygons larger that 25 ha were erroneously omitted.

To compare the overall class statistics produced by both methods, the number of pixels/1000 identified for each CORINE class were isolated from Table 12 into Table 13 and plotted in a scatter plot (Figure 10). A line shows the case where class pixel counts are equal for the two methods. Overall, the statistics compare well. There are some outliers however: *road and rail* (1.2.2), *dump sites* (1.3.2), *mixed cultivation patterns* (2.4.2), *broadleaved forest* (3.1.1), *mixed forest* (3.1.3) and *peat bogs* (4.1.2). The difference in statistics for the two 1.*.* classes have been exaggerated by the logarithmic scale used in the scatter plot. Since the classes were manually identified in both methods, the relatively small disparity (*road and rail*: 0.05 pixels/1000; *dump sites*: 0.10 pixels/1000) is caused by human error (e.g. accidentally overlooking one site or wrongly including or excluding polygons which are close to the 25 ha limit). The difference in statistics for *mixed cultivation patterns* (11.1 pixels/1000) reflects the very considerable difficulty the manual interpreter had in searching for small isolated pockets of mosaics of two or more cover-types. The *broadleaved forest* (11.2 pixels/1000) differences relate largely to the highly fragmented patterns of woodland in Britain, with complex outlines, often as linear features (near the 100 m limit) or in small copses near the 25 ha limit, all potentially leading to interpretation differences. The differences with *mixed forest* (2.92 pixels/1000) are probably caused by the difficulties the manual interpreter had in deciding when to aggregate polygons into mixed classes; to some extent the higher estimate of *mixed forest* by manual methods explains the manually-based lower estimate of pure *broadleaved forest*. The difference for *peat bogs* (0.5 pixels/1000) is caused by the complex nature of semi-natural vegetation types and the difficulty of differentiating *peat bog* from other cover types without local knowledge.

5. CONCLUSION

The overall 83% correspondence is in accord with the intended 85% overall 'accuracy' required of CORINE Land Cover. Given that the manual mapping, used to check the correspondence, is probably no better than 90% correct (a 'best guess' but we have no 'ground truth' data to prove or disprove that assessment) the value suggests that the automated product may have achieved a similar level of 'accuracy'. This may at first seem remarkable in view of the suggested 80-85% accuracy of the input LCMGB; however, it suggests very strongly that the generalisation successfully removes 'noise' in the original data and that (within the generalisation rules of CORINE) the output is an improvement on the original.

The achievement of just 71% for marginal land shows the difficulty of mapping in this complex landscape with its small-scale patterns of highly variable land use. It is clear that scarce cover types, especially those which are also dissected into many small units at, near, or below the 25 ha minimum mappable unit, are highly variable in their interpretation between the manual and semi-automated methods. The 71% probably represents the overlap between two products both less accurate than the national average, each perhaps 80-85% correct. Thankfully, the marginal landscape is the least extensive of the four types so its contribution of error to the national total does not substantially impact upon the overall result.

The 81% result for and pastural land, is also lower than the national average, again reflecting the greater complexity of this landscape, though such complexity is less than that of the marginal type. The result could still imply the overlap between two products each with near 90% accuracy.

The correspondence for arable land (86%), and upland (89%) at the other hand is <u>better</u> than might have been expected. The results suggests that, in these simpler landscapes, the generalisation to CORINE format is removing erroneous 'noise' in the per-pixel classification with the greatest effect.

In final conclusion, it is believed that the very similar appearance of both manual & automated outputs, the high level of agreement in cover statistics for test sites, and the overall levels of correspondence, demonstrate that the procedure has achieved the desired output and that the CORINE Land Cover Map of Great Britain conforms with requirements and can be integrated into the European dataset.

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Table 2. The correspondence per 1000 pixels between manual and semi-automated method for the test site representing arable landscape in Cambridgeshire

MANUAL

AUTOMATED: CORINE class	111 - cont urb	112 - discont	121 - indust	124 - airport	131 - mineral	133 - constr	141 - green urb	142 - recreat	211 - arable	231 - pasture	242 - mixed cult	243 - agric/nat	311 - broadlf	312 - conifer	313 - mixed woodl	321 - nat grass	324 - trans woodl	332 - bare rock	512 - wtrbody	cover / 1000	% auto corr.
111 - cont urb	**2.8**	1.4							0.0	0.3										4.5	**61**
112 - discont	0.9	**28.9**		0.2	0.0	0.0		0.0	9.2	1.6			0.2						0.0	41.0	**71**
121 - indust		0.0	**1.5**						0.0	0.0										1.5	
124 - airport		0.1		**9.0**					1.2	0.2										10.5	**86**
131 - mineral	0.0	0.0			**4.9**				0.2	0.1									0.1	5.2	
133 - constr		0.0				**1.3**			0.2	0.0										1.5	
141 - green urb		0.0							0.3	1.5										1.9	
142 - recreat		0.7						**3.2**	1.0	0.7										5.5	**58**
211 - arable		9.2		0.3	0.0	0.0		0.3	**717.0**	17.3			3.3	0.2		0.3			1.6	749.5	**96**
231 - pasture	0.2	11.5		0.0	0.2	0.2		0.8	39.2	**91.1**			0.6			0.0			1.1	144.8	**63**
242 - mixed cult	0.1	1.0		0.2	0.1				7.2	1.2			0.1	0.0		0.2			0.4	10.5	
243 - agric/nat									0.3	0.1			0.0						0.2	0.5	
311 - broadlf		0.1							1.1	0.0			**5.5**	0.2						6.9	**80**
312 - conifer									0.3	0.1			0.4	**0.4**						1.2	**32**
313 - mixed woodl									0.1				0.3	0.2						0.6	**32**
321 - nat grass		0.2							2.4	0.1						**1.4**			0.0	4.1	**34**
324 - trans woodl									0.1	0.0			0.4							0.5	
332 - bare rock				0.3					0.5											0.8	
512 - wtrbody		0.1			0.0				0.6	0.4			0.0						**7.8**	8.9	**88**
cover / 1000	3.9	53.3	1.5	10.1	5.2	1.5		4.3	780.9	114.6			10.7	1.0		2.0			11.1	1000.0	
% manual corr.	**71**	**54**	**100**	**89**	**93**	**87**		**74**	**92**	**79**			**51**	**41**		**71**			**70**		

Total pixels interpreted = 1224000000

Total matching = 874.7 pixels / 1000

Table 3. The correspondence per 1000 pixels between manual and semi-automated method for the test site representing pastural landscape in Devon

MANUAL

AUTOMATED: Corine Value	112 - discont	121 - indust.	123 - port areas	124 - airports	131 - mineral	142 - recreat.	211 - arable	231 - pasture	242 - cultivate	243 - agric/nat	311 - broadlf	312 - conifer	313 - mixed forest	321 - nat grass	322 - moors/heath	332 - bare rock	423 - intert. flats	522 - estuaries	523 - sea/ocean	cover / 1000	% auto corr.
112 - discont	**26.5**	0.3	0.0	0.3	1.1	0.2	0.3	8.9		0.4	0.1			0.2			0.2		0.1	38.6	**69**
121 - indust	0.2	**1.2**						0.0									0.0			1.4	**83**
123 - port areas	0.0		**0.4**			0.0											0.0			0.4	**88**
124 - airports	0.2			**2.4**				0.4			0.0									2.9	**80**
131 - mineral	0.8	0.1			**22.3**			1.7		0.2	0.0			0.1						25.2	**89**
142 - recreat	0.4		0.0			**1.5**	0.0	3.1		0.6	0.0						0.1		0.0	5.8	**26**
211 - arable	0.0			0.0		0.4	**11.0**	12.6		0.3	0.4			0.1			0.1		0.0	25.0	**44**
231 - pasture	4.9	0.1	0.1	0.5	1.0	0.6	8.1	**582.0**		1.4	14.2	0.1	0.3	1.7			1.7	0.0	0.3	617.0	**94**
242 - cultivate	0.4			0.5	0.0	0.0	2.0	16.0		0.4	0.3						0.3		0.1	20.0	
243 - agric/nat	0.0							2.7			0.4			0.0			0.1	0.0	0.0	3.2	
311 - broadlf	0.2			0.0	0.1		0.3	20.8		0.0	**24.2**	0.2	1.0	0.6			0.4	0.0		47.8	**51**
312 - conifer								0.2			0.1	**0.7**	0.3							1.4	**49**
313 - mixed forest																					
321 - nat grass	0.1	0.1			0.3		0.2	6.5			0.1			**5.7**						12.9	**44**
322 - moors/heath	0.0							0.1						0.2						0.4	
332 - bare rock		0.6			0.7		0.4	0.8			0.1			0.1						2.7	
423 - intert. flats	0.7		0.0			0.5	0.0	3.6			0.0						**9.8**	0.1	0.0	14.8	**66**
522 - estuaries								0.0									0.4	**0.6**		1.1	**58**
523 - sea/ocean	0.1		0.0			0.1	0.3	1.6		0.0							2.3	**0.0**	**174.9**	179.3	**98**
cover / 1000	34.4	2.3	0.5	3.6	25.5	3.3	22.6	660.9		3.4	40.2	1.0	1.7	8.6			15.7	0.9	175.4	1000.0	
% manual corr.	**77**	**52**	**69**	**65**	**87**	**45**	**49**	**88**			**60**	**71**		**66**			**63**	**71**	**100**		

Total pixels interpreted = 1201635000 **Total matching = 863 pixels / 1000**

Table 4. The correspondence per 1000 pixels between manual and semi-automated method for the test site representing marginal landscape in west Scotland

AUTOMATED / CORINE class	112 - cont urb	142 - recreat	231 - pasture	311 - broadlf	312 - conifer	321 - nat grass	322 - moors/heath	324 - trans wood	331 - beaches	332 - bare rock	412 - peat bogs	512 - wtrbody	522 - estuaries	523 - sea/ocean	cover / 1000	% auto corr.
112 - cont urb	**0.9**		0.3			0.4			0.1						1.8	**52**
142 - recreat																
231 - pasture	0.1	0.2	**33.6**			7.6	3.7				0.1	0.1		0.6	46.0	**73**
311 - broadlf			0.1			0.1	0.4				0.3				0.9	
312 - conifer	0.0	0.1	1.7		**223.7**	5.2	4.4		0.0			0.5		0.3	236.0	**95**
321 - nat grass	0.1	0.0	6.0			**168.9**	44.5		0.1		0.0	0.3		0.7	220.7	**77**
322 - moors/heath	0.1		9.3			57.2	**248.7**		1.2		1.5	0.8		0.9	319.8	**78**
324 - trans wood			0.1			0.2	2.5	**29.1**						0.0	31.9	**91**
331 - beaches	0.5		0.0			0.1			**1.3**					0.3	2.2	**58**
332 - bare rock			0.0			0.2									0.3	
412 - peat bogs						1.2	1.3				**0.0**	0.0			2.5	**1**
512 - wtrbody			0.8			1.3	1.0					**29.3**			32.4	**91**
522 - estuaries																
523 - sea/ocean	0.1		0.4			3.0	1.1		0.5			0.5		**99.9**	105.5	**95**
cover / 1000	1.9	0.2	52.3		223.7	245.6	307.6	29.1	3.3		2.0	31.6		102.7	1000.0	
% manual corr.	**50**		**64**		**100**	**69**	**81**	**100**	**39**		**1**			**97**		

MANUAL

Total pixels interpreted = 1200884375 **Total matching = 836 pixels / 1000**

Table 5. The correspondence per 1000 pixels between manual and semi-automated method for the test site representing marginal landscape in Wales

MANUAL

AUTOMATED Corine Value	111 - cont urb	112 - discont	121 - indust.	122 - road and rail	123 - port areas	131 - mineral	132 - dump sites	142 - recreat.	211 - arable	231 - pasture	242 - cultivate	243 - agric/nat	311 - broadlf	312 - conifer	313 - mixed forest	321 - nat grass	322 - moors/heath	332 - bare rock	412 - peat bogs	421 - salt marshes	512 - water bodies	522 - estuaries	cover / 1000	% auto corr.
111 - cont urb	**3.7**	2.1	0.7							0.2			0.0			0.1						0.2	6.9	**53**
112 - discont	1.8	**78.0**	3.7	0.3	0.0	1.1	0.0	0.2	0.4	12.1	0.0	0.7	1.4	0.2	0.2	2.1	1.2	0.0			0.0	0.0	103.3	**76**
121 - indust		2.1	**4.4**						0.2	0.5		0.1	0.0			0.1	0.2					0.1	7.7	**57**
122 - road/rail			0.1	**0.0**						0.1													0.2	**4**
123 - port areas	0.0	0.0			**1.7**					0.0												0.1	1.9	**93**
131 - mineral		0.2	0.0			**2.3**				0.5						0.1	0.1						3.0	**74**
132 - dump sites							**0.3**			0.0													0.3	**98**
142 - recreat		0.1	0.0					**3.1**	0.1	4.1			0.1	0.0		0.4	0.3	0.1					8.3	**38**
211 - arable		1.0	0.0			0.4			**8.7**	5.5	0.3	0.1	0.1	0.0	0.0	0.5						0.0	16.8	**52**
231 - pasture	0.2	12.4	1.0	0.0	0.0	0.9	0.0	0.7	4.0	**347.2**	0.3	3.2	8.7	2.1	2.5	14.7	10.5	0.2			0.1	0.3	409.0	**85**
242 - cultivate	0.2	5.5	0.6		0.4	0.2		0.0	2.0	7.0		0.8	0.4	0.4	0.2	0.8	0.0	0.3				0.2	18.9	**0**
243 - agric/nat		0.3					0.0			0.9			0.3	0.0		0.1							1.6	
311 - broadlf	0.0	3.9	0.1	0.3		0.3	0.3	0.1	0.9	40.9	0.1	1.0	**33.2**	14.5	11.4	5.2	1.4				0.1		113.8	**29**
312 - conifer		0.1				0.0			0.2	2.5		0.0	1.8	**11.4**	2.1	0.8	0.4				0.2		19.4	**59**
313 - mixed forest		0.1						0.0	0.1	1.9			1.4	1.2	**1.9**	0.4	0.1						7.1	**26**
321 - nat grass	0.1	2.3	0.3			1.4		0.7	0.1	49.3	0.2	0.3	6.8	3.2	2.9	**76.5**	9.6	0.6			0.2		154.3	**50**
322 - moors/heath	0.1	2.6	0.5	0.1		1.7		0.2	0.1	17.7		0.7	5.5	4.6	1.1	10.6	**70.0**				0.1		115.4	**61**
332 - bare rock		0.8	0.0			1.3				0.4			0.0	0.1		0.1	0.2						3.0	**7**
412 - peat bogs										0.0						0.2							0.2	
421 - salt marshes			0.0						0.0	0.0												0.2	0.3	
512 - water bodies	0.0	0.1	0.0		0.4					0.1			0.0	0.2			0.0				**3.1**	0.3	4.2	**1**
522 - estuaries	0.0		0.1		0.1				0.0	0.0												**4.2**	4.4	**95**
cover / 1000	6.0	111.6	11.7	0.6	2.6	9.5	0.7	4.9	16.7	490.9	0.9	6.9	59.8	37.9	22.2	112.5	93.9	1.3			3.7	5.6	1000.0	
% manual corr.	**61**	**70**	**37**	**2**	**67**	**24**	**41**	**63**	**52**	**71**		**15**	**56**	**30**	**8**	**68**	**74**				**4**	**76**		

Total pixels interpreted = 1229935625 **Total matching = 650 pixels / 1000**

Table 6. The correspondence per 1000 pixels between manual and semi-automated method for the test site representing upland landscape in east Scotland

MANUAL

AUTOMATED — CORINE class	142 - recreat.	231 - pasture	242 - complex Cult	243 - agri/nat	311 - broadlf	312 - conifer	321 - nat grass	322 - moors/heath	324 - trans wood	332 - bare rock	412 - peat bogs	512 - wtrbody	cover / 1000	% auto corr.
142 - recreat.		0.0					0.0	0.9		0.0			0.9	
231 - pasture		**6.8**					5.5	1.0				0.0	13.3	
242 - complex Cult							0.0						0.0	
243 - agri/nat							0.0						0.0	
311 - broadlf							0.3	0.0					0.3	
312 - conifer		0.2				**69.1**	1.1	3.1				0.2	73.6	**94**
321 - nat grass		0.3					**27.6**	14.0		0.8		0.0	42.7	**65**
322 - moors/heath		1.2					32.5	**783.3**		12.3		1.1	830.4	**94**
324 - trans wood		0.1					0.7	0.2					1.0	
332 - bare rock							0.5	9.8		**20.5**		0.2	30.9	
412 - peat bogs								2.5		0.0			2.5	
512 - wtrbody		0.0					0.1	0.6		0.0		**3.6**	4.4	**82**
cover / 1000		8.6				69.1	68.4	815.3		33.6		5.1	1000.0	
% manual corr.		**80**				**100**	**40**	**96**		**61**		**71**		

Total pixels interpreted = 1200884375 **Total matching = 911 pixels / 1000**

Table 7. Correspondence per 1000 pixels between manual and semi-automated method for arable landscape

AUTOMATED \ MANUAL	111 - cont urb	112 - discont	121 - indust	124 - airport	131 - mineral	133 - constr	141 - green urb	142 - recreat	211 - arable	231 - pasture	242 - mixed cult	243 - agric/nat	311 - broadlf	312 - conifer	313 - mixed forest	321 - nat grass	322 - moors/heath	324 - trans woodl	331 - beaches	332 - bare rock	412 - peat bogs	512 - water bodies	522 - estuaries	523 - sea/ocean	cover/1000	% auto corr
111 - cont urb	2.40	1.21							0.01	0.25															3.87	**62**
112 - discont	0.76	27.45	0.59	0.14	0.00	0.03		0.02	7.57	2.00	0.01		0.13									0.01	0.00		38.70	**71**
121 - indust		0.28	1.38						0.00	0.02		0.02													1.70	**81**
124 - airport		0.10		7.40					0.98	0.15															8.62	**86**
131 - mineral	0.00	0.03			4.00				0.13	0.05												0.04			4.26	**94**
133 - constr		0.03				1.09			0.15	0.01															1.27	**85**
141 - green urb		0.03							0.27	1.26															1.57	
142 - recreat		0.56	0.00					2.61	0.85	1.27			0.01												5.29	**49**
211 - arable		7.54	0.03	0.27	0.00	0.02		0.25	588.07	15.18	0.24		2.71	0.16		0.29						1.25			616.00	**95**
231 - pasture	0.16	10.26	0.19	0.02	0.17	0.12		0.64	32.43	115.30	0.28	0.02	0.99	0.02	0.15	3.16	0.66					0.92		0.13	165.62	**70**
242 - mixed cult	0.06	0.85	0.04	0.19	0.10				6.00	1.65		0.15	0.08	0.03		0.16						0.34			9.66	
243 - agric/nat									0.23	0.28			0.01			0.00						0.15			0.67	
311 - broadlf		0.07							1.10	1.38	0.07		5.96	0.27	0.26	0.01									9.13	**65**
312 - conifer									0.27	0.61			0.41	40.66	0.16	1.10	0.64					0.25		0.00	44.09	**92**
313 - mixed forest									0.12	0.01			0.22	0.16	0.21	0.00									0.73	**29**
321 - nat grass		0.13							2.00	2.84	0.16				0.03	31.78	1.17		0.04		0.00	0.03		0.15	38.33	**83**
322 - moors/heath										3.01						7.95	12.00				0.11	0.14		0.07	23.28	**52**
324 - trans woodl									0.09	0.05			0.31			0.15	0.98	3.35							4.93	**68**
331 - beaches																0.03			0.02					0.10	0.15	**14**
332 - bare rock				0.27					0.38																0.65	
412 - peat bogs																0.18	0.02				0.01				0.21	**6**
512 - water bodies		0.06	0.01		0.02				0.50	0.61			0.02			0.38	0.11					12.93			14.62	**88**
522 - estuaries																										
523 - sea/ocean										0.03						0.49	0.05		0.02					6.07	6.67	
cover/1000	3.38	48.60	2.23	8.29	4.29	1.26		3.53	641.12	145.94	0.76	0.19	10.84	41.29	0.81	45.71	15.64	3.35	0.08		0.12	16.05	0.00	6.53	1000	
% manual corr	**71**	**56**	**62**	**89**		**87**		**74**	**92**	**79**			**55**	**98**	**26**	**70**		**100**	**27**		**10**	**81**		**93**		

Total pixels interpretated = 1490375000

Total matching = 862.68 pixels/1000

Table 8. Correspondence per 1000 pixels between manual and semi-automated method for pastural landscape

AUTOMATED \ MANUAL	111 - cont urb	112 - discont	121 - indust	123 - port areas	124 - airport	131 - mineral	132 - dump sites	142 - recreat	211 - arable	231 - pasture	242 - mixed cult	243 - agric/nat	311 - broadlf	312 - conifer	313 - mixed forest	321 - nat grass	322 - moors/heath	324 - trans woodl	331 - beaches	332 - bare rock	412 - peat bogs	421 - salt marshes	423 - intert flats	512 - water bodies	522 - estuaries	523 - sea/ocean	cover/1000	% auto corr
111 - cont urb	2.53	1.45	0.39							0.09			0.00			0.02									0.11		4.6	**55**
112 - discont	1.00	52.91	1.41	0.03	0.18	0.78	0.00	0.12	0.46	11.71	0.00	0.55	0.61	0.07	0.09	0.58							0.17	0.01	0.01	0.09	70.8	**75**
121 - indust		1.26	2.34						0.11	0.18		0.07	0.02										0.01		0.09		4.1	**57**
123 - port areas	0.00	0.03		1.50				0.01		0.00													0.03		0.06		1.6	**92**
124 - airport		0.14			1.65					0.26			0.01														2.1	**80**
131 - mineral		0.56	0.04			15.84				1.16		0.16	0.00			0.08											17.8	**89**
132 - dump sites							0.22			0.01																	0.2	**98**
142 - recreat		0.32	0.03	0.03				1.51	0.03	3.87		0.45	0.09	0.00		0.18							0.07			0.01	6.6	**23**
211 - arable		0.71			0.00	0.01		0.27	14.01	11.00		0.30	0.34	0.01	0.00	0.09							0.09	0.05	0.04	0.01	26.9	**52**
231 - pasture	0.13	7.97	0.30	0.05	0.35	0.77	0.03	0.68	7.88	528.14	0.00	2.11	11.45	0.32	0.55	2.98	0.38						1.22	0.06	0.20	0.19	565.7	**93**
242 - mixed cult	0.11	3.66	0.21	0.28	0.32	0.03		0.02	2.41	14.23		0.66	0.43	0.12	0.14	0.44							0.23		0.13	0.07	23.5	
243 - agric/nat		0.21					0.03			2.29			0.35	0.00		0.00							0.06		0.02	0.00	3.0	
311 - broadlf		2.34	0.00		0.03	0.12	0.25	0.04	0.40	28.84		0.29	27.65	2.40	4.93	2.19	0.09						0.30	0.01	0.02		69.9	**40**
312 - conifer		0.01							0.10	0.37			0.26	4.97	0.50	0.24	0.53							0.01		0.00	7.0	**71**
313 - mixed forest		0.01						0.00	0.04	0.99			0.10	0.31	0.55												2.0	**28**
321 - nat grass	0.02	0.89	0.04			0.35		0.00	0.19	19.21		0.17	1.17	0.36	1.05	16.85	0.51		0.02		0.01			0.11			41.0	**41**
322 - moors/heath		0.11								0.48		0.23	0.02	0.11	0.05	2.50	3.60		0.30		0.28			0.01			7.7	**47**
324 - trans woodl																0.01	0.52	0.18									0.7	**25**
331 - beaches																			0.01								0.0	**100**
332 - bare rock		0.09	0.41			0.61			0.27	0.65			0.10	0.04		0.09											2.3	
412 - peat bogs																0.15											0.1	
421 - salt marshes			0.00						0.01	0.02															0.15		0.2	
423 - intert flats		0.46		0.01				0.36	0.01	2.55			0.01										6.89		0.10	0.02	10.4	**66**
512 - water bodies	0.00	0.05	0.01	0.29						0.07						0.09	0.07							1.16	0.19		1.9	**60**
522 - estuaries	0.02		0.07	0.05					0.00	0.01													0.31		2.82		3.3	**86**
523 - sea/ocean		0.07		0.00				0.06	0.20	1.11		0.03				0.01	0.09		0.00				1.63	0.04	0.03	123.34	126.6	**97**
cover/1000	3.8	73.2	5.3	2.2	2.5	18.5	0.5	3.1	26.1	627.2	0.0	5.0	42.6	8.7	7.9	26.5	5.8	0.2	0.3		0.3		11.0	1.5	4.0	123.7	1000	
% manual corr	**66**	**72**	**45**	**67**	**65**	**86**	**41**	**49**	**54**	**84**			**65**	**57**	**7**	**64**	**62**	**100**	**4**				**63**	**78**	**71**	**100**		

Total pixels interpreted = 1712610000 **Total matching = 808.6882 pixels /1000**

Table 9. Correspondence per 1000 pixels between manual and semi-automated method for upland landscape

MANUAL

AUTOMATED CORINE class	112 - discont	142 - recreat	231 - pasture	242 - mixed cult	243 - agric/nat	311 - broadlf	312 - conifer	321 - nat grass	322 - moors/heath	324 - trans woodl	331 - beaches	332 - bare rock	412 - peat bogs	512 - wtrbody	523 - sea/ocean	cover/1000	% auto corr
112 - discont	0.68		0.19					0.33			0.09					1.28	**53**
142 - recreat			0.01					0.00	0.60			0.00				0.61	
231 - pasture	0.05	0.02	13.85					6.05	1.96				0.11	0.01	0.32	22.37	**62**
242 - mixed cult								0.02								0.02	
243 - agric/nat								0.00								0.00	
311 - broadlf			0.00					0.20	0.00				0.22			0.43	
312 - conifer	0.03	0.00	0.66				88.59	1.78	3.40		0.02			0.21	0.25	94.94	**93**
321 - nat grass	0.02	0.00	1.39					58.27	20.83		0.02	0.58	0.01	0.13	0.38	81.65	**71**
322 - moors/heath	0.11		3.04					39.60	643.29		0.57	8.29	0.74	0.99	0.57	697.18	**92**
324 - trans woodl			0.05					0.52	0.56	3.74					0.01	4.88	**77**
331 - beaches	0.36		0.03					0.06			0.93				0.11	1.49	**62**
332 - bare rock			0.01					0.48	6.87			14.29		0.12		21.76	**66**
412 - peat bogs								0.21	1.82			0.00		0.00		2.04	
512 - wtrbody			0.27					0.52	0.71			0.01		16.43		17.94	**92**
523 - sea/ocean	0.07		0.25					1.69	0.68		0.39			0.33	50.00	53.41	**94**
cover/1000	1.32	0.02	19.75				88.59	109.74	680.72	3.74	2.02	23.17	1.07	18.22	51.64	1000	
% manual corr	**51**		**70**				**100**	**53**	**95**	**100**	**46**	**62**		**90**	**97**		

Total pixels interpreted = 1635504375 **Total matching = 890.06 pixels/1000**

Table 10. Correspondence per 1000 pixels between manual and semi-automated method for marginal landscape

AUTOMATED \ MANUAL	111 - cont urb	112 - discont	121 - indust	122 - road/rail	131 - mineral	142 - recreat	211 - arable	231 - pasture	242 - mixed cult	243 - agric/nat	311 - broadlf	312 - conifer	313 - mixed forest	321 - nat grass	322 - moors/heath	324 - trans woodl	332 - bare rock	412 - peat bogs	512 - water bodies	523 - sea/ocean	cover/1000	% auto corr
111 - cont urb		0.10	0.18					0.08						0.03							0.39	
112 - discont	0.39	26.58	1.40	0.28	1.11	0.16		3.68		0.29	0.66	0.13	0.03	1.56	1.25		0.02				37.54	**71**
121 - indust		0.18	2.11					0.31						0.12	0.21						2.93	**72**
122 - road/rail			0.15	0.01				0.08													0.24	**4**
131 - mineral		0.17	0.00		2.07			0.52						0.06	0.05						2.88	**72**
142 - recreat		0.00				2.56	0.01	0.83			0.01			0.11	0.38		0.15				4.06	**63**
211 - arable		0.09			0.40		0.94	1.41			0.05			0.42							3.31	**28**
231 - pasture	0.02	5.26	0.42	0.02	0.82	0.51	0.68	157.14		1.67	6.19	1.76	1.88	13.70	11.45		0.19		0.00		201.70	**78**
242 - mixed cult		0.77	0.26		0.18	0.04	0.46	2.06		0.09	0.11	0.15		0.17	0.00		0.34				4.63	
243 - agric/nat								0.04			0.26			0.06							0.36	
311 - broadlf	0.00	0.83	0.10	0.27	0.27	0.02	0.47	20.10		0.67	17.10	11.63	5.37	2.81	1.74				0.12		61.49	**28**
312 - conifer		0.05			0.04	0.05	0.04	2.61		0.05	1.53	128.36	1.57	2.99	1.73				0.27		139.28	**92**
313 - mixed forest		0.06				0.02		0.55			1.30	0.81	0.85	0.40	0.11						4.10	**21**
321 - nat grass	0.03	1.20	0.34		1.26	0.69		30.71		0.03	5.47	2.75	1.46	140.17	37.95		0.62		0.19		222.87	**63**
322 - moors/heath	0.06	2.59	0.48	0.05	1.74	0.17	0.13	20.31		0.36	5.67	4.59	1.06	33.69	209.97		1.04		0.42	0.02	282.35	**74**
324 - trans woodl																19.74					19.74	**100**
332 - bare rock		0.73	0.05		1.10			0.38			0.03			0.07	0.67		1.04				4.07	**26**
412 - peat bogs								0.00						0.72	1.29		0.03				2.04	
512 - water bodies								0.07			0.01	0.23		0.16	0.43				3.99		4.89	**82**
523 - sea/ocean														0.05						1.08	1.13	**96**
cover/1000	0.50	38.60	5.48	0.63	8.99	4.22	2.73	240.90		3.15	38.40	150.42	12.21	197.27	267.24	19.74	3.44		4.99	1.10	1000	
% manual corr		**69**	**38**	**2**	**23**	**61**	**35**	**65**			**45**	**85**	**7**	**71**	**79**	**100**	**30**		**80**	**99**		

Total pixels interpreted = 1192450625

Total matching = 713.717 pixels/1000

Table 12. Correspondence per 1000 pixels between manual and semi-automated method for the weighted average of the four landscape types found in Great Britain: arable, pastural, upland and marginal

MANUAL

AUTOMATED CORINE Class	111 - cont urb	112 - discont	121 - indust	122 - road/rail	123 - port areas	124 - airport	131 - mineral	132 - dump sites	133 - constr	141 - green urb	142 - recreat	211 - arable	231 - pasture	242 - mixed cult	243 - agric/nat	311 - broadlf	312 - conifer	313 - mixed forest	321 - nat grass	322 - moors/heath	324 - trans woodl	331 - beaches	332 - bare rock	412 - peat bogs	421 - salt marshes	423 - intert flats	512 - water bodies	522 - estuaries	523 - sea/ocean	cover/1000	% auto corr
111 - cont urb	1.61	0.88	0.15									0.00	0.12			0.00			0.01									0.04		2.81	**57**
112 - discont	0.62	29.58	0.82	0.03	0.01	0.10	0.39	0.00	0.01		0.06	2.64	4.94	0.00	0.21	0.32	0.04	0.03	0.45	0.16		0.02	0.00			0.06	0.01	0.00	0.03	40.55	**73**
121 - indust		0.52	1.47									0.04	0.10		0.03	0.01			0.02	0.03						0.00		0.03		2.24	**66**
122 - road/rail			0.02	0.00									0.01																	0.03	
123 - port areas	0.00	0.01			0.48						0.00		0.00													0.01		0.02		0.53	**92**
124 - airport		0.08				2.97						0.32	0.13			0.00														3.51	**85**
131 - mineral	0.00	0.21	0.01				6.69					0.04	0.46		0.05	0.00			0.03	0.01							0.01			7.52	**89**
132 - dump sites								0.07					0.00																	0.07	**98**
133 - constr		0.01							0.36			0.05	0.00																	0.42	**85**
141 - green urb		0.01										0.09	0.42																	0.52	
142 - recreat		0.29	0.01		0.01						1.67	0.29	1.77		0.14	0.03	0.00		0.07	0.18			0.02			0.02			0.00	4.51	**37**
211 - arable		2.72	0.01			0.09	0.05		0.01	0.17	198.44	8.73	0.08	0.10	1.01	0.05	0.00	0.17								0.03	0.43	0.01	0.00	212.11	**94**
231 - pasture	0.10	6.62	0.21	0.00	0.02	0.12	0.40	0.01	0.04	0.50	13.31	231.18	0.09	0.89	4.79	0.33	0.46	5.06	2.20			0.02	0.02	0.39	0.33	0.06	0.17	267.34	**86**
242 - mixed cult	0.06	1.56	0.11		0.09	0.17	0.07			0.01	2.81	5.40		0.27	0.18	0.07	0.04	0.22	0.00			0.04		0.08	0.11	0.04	0.02	11.35	
243 - agric/nat		0.07						0.01			0.08	0.83			0.15	0.00		0.01						0.02	0.05	0.01	0.00	1.22	
311 - broadlf	0.00	0.88	0.01	0.03		0.01	0.07	0.08		0.01	0.55	12.26	0.02	0.18	13.02	2.31	2.34	1.11	0.25				0.05	0.10	0.02	0.01		33.31	**39**
312 - conifer		0.02					0.00			0.01	0.12	0.79		0.01	0.41	50.72	0.41	1.21	1.36		0.00				0.17		0.06	55.28	**92**
313 - mixed forest		0.01								0.00	0.05	0.39			0.27	0.25	0.35	0.05	0.01									1.40	**25**
321 - nat grass	0.01	0.48	0.05				0.27			0.09	0.72	11.26	0.05	0.06	1.05	0.46	0.53	46.33	9.91		0.02	0.21	0.01		0.10		0.14	71.75	**65**
322 - moors/heath	0.01	0.38	0.06	0.01			0.22			0.02	0.02	4.34		0.12	0.71	0.61	0.15	16.45	174.86		0.22	1.98	0.29		0.32		0.15	200.92	**87**
324 - trans woodl												0.03	0.03			0.10			0.17	0.62	4.45							0.00	5.40	**82**
331 - beaches		0.08											0.01						0.02			0.22						0.06	0.39	**56**
332 - bare rock		0.12	0.14			0.09	0.33					0.21	0.26			0.04	0.01		0.14	1.62			3.32				0.03			6.31	**53**
412 - peat bogs													0.00						0.24	0.57			0.00	0.00			0.00			0.82	**0**
421 - salt marshes			0.00									0.00	0.01															0.05		0.06	
423 - intert flats		0.15			0.00						0.12	0.00	0.82			0.00										2.23		0.03	0.00	3.36	**66**
512 - water bodies	0.00	0.03	0.01		0.09		0.01					0.17	0.29			0.01	0.03		0.29	0.27			0.00				8.80	0.06		10.05	**88**
522 - estuaries	0.01		0.02		0.02							0.00	0.00													0.10		0.91		1.06	**86**
523 - sea/ocean		0.04			0.00						0.02	0.06	0.42		0.01				0.55	0.20		0.09				0.53	0.09	0.01	53.14	55.16	**96**
cover/1000	2.40	44.76	3.11	0.08	0.72	3.55	8.51	0.17	0.41		2.68	220.05	284.99	0.25	2.08	22.10	54.88	4.32	72.61	192.23	4.45	0.58	5.60	0.37		3.56	10.46	1.28	53.78	1000	
% manual corr	**67**	**66**	**47**		**67**	**84**	**79**	**41**	**87**		**62**	**90**	**81**			**59**	**92**	**8**	**64**	**91**	**100**	**37**	**59**	**1**		**63**	**84**	**71**	**99**		

Total pixels interpreted = 1537632419

Total matching = 832.87 pixels/1000

Table 13. Number of pixels/1000 identified for each CORINE class by the manual and semi-automated method

CORINE Class	pixels/1000 automated	pixels/1000 manual
111 - cont urb	2.81	2.40
112 - discont	40.55	44.76
121 - indust	2.24	3.11
122 - road/rail	0.03	0.08
123 - port areas	0.53	0.72
124 - airport	3.51	3.55
131 - mineral	7.52	8.51
132 - dump sites	0.07	0.17
133 - constr	0.42	0.41
141 - green urb	0.52	0.00
142 - recreat	4.51	2.68
211 - arable	212.11	220.05
231 - pasture	267.34	284.99
242 - mixed cult	11.35	0.25
243 - agric/nat	1.22	2.08
311 - broadlf	33.31	22.10
312 - conifer	55.28	54.88
313 - mixed forest	1.40	4.32
321 - nat grass	71.75	72.61
322 - moors/heath	200.92	192.23
324 - trans woodl	5.40	4.45
331 - beaches	0.39	0.58
332 - bare rock	6.31	5.60
412 - peat bogs	0.82	0.37
421 - salt marshes	0.06	0.00
423 - intert flats	3.36	3.56
512 - water bodies	10.05	10.46
522 - estuaries	1.06	1.28
523 - sea/ocean	55.16	53.78

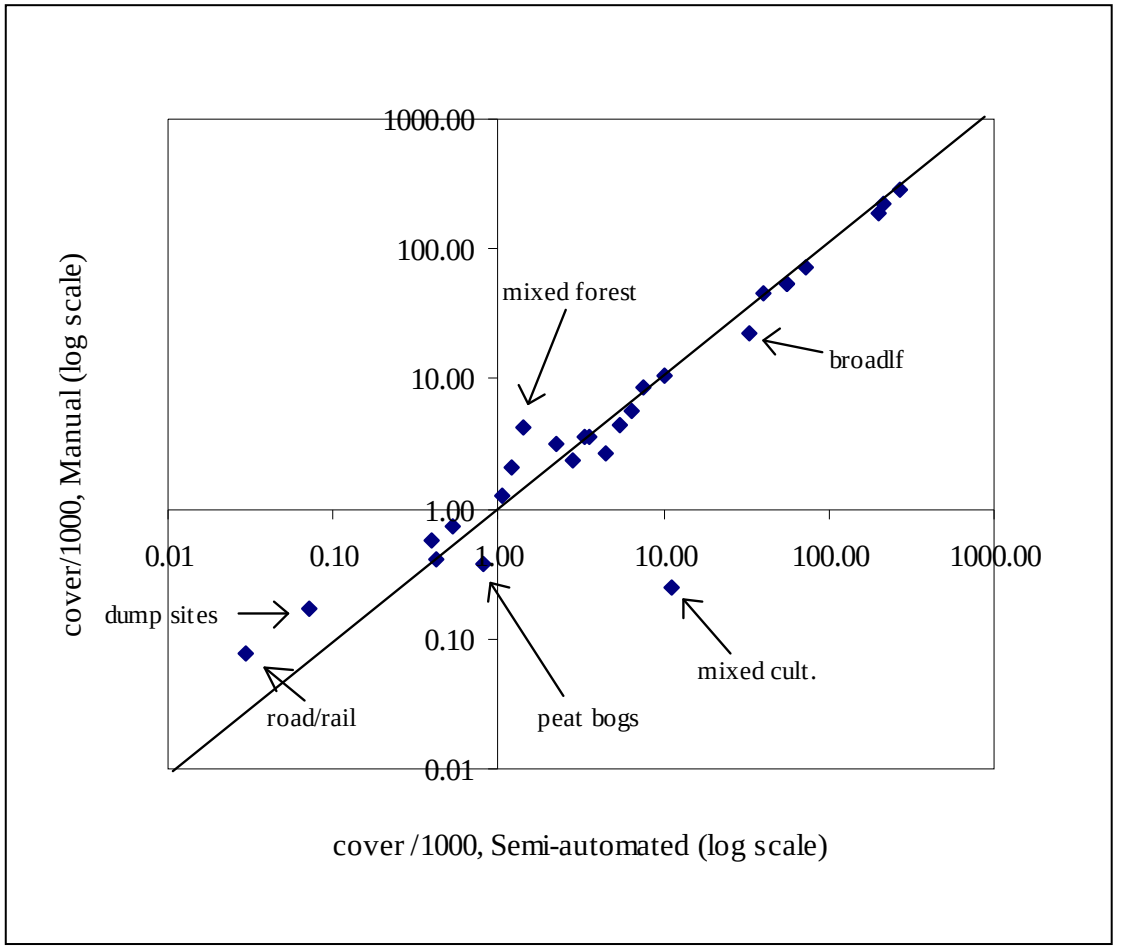
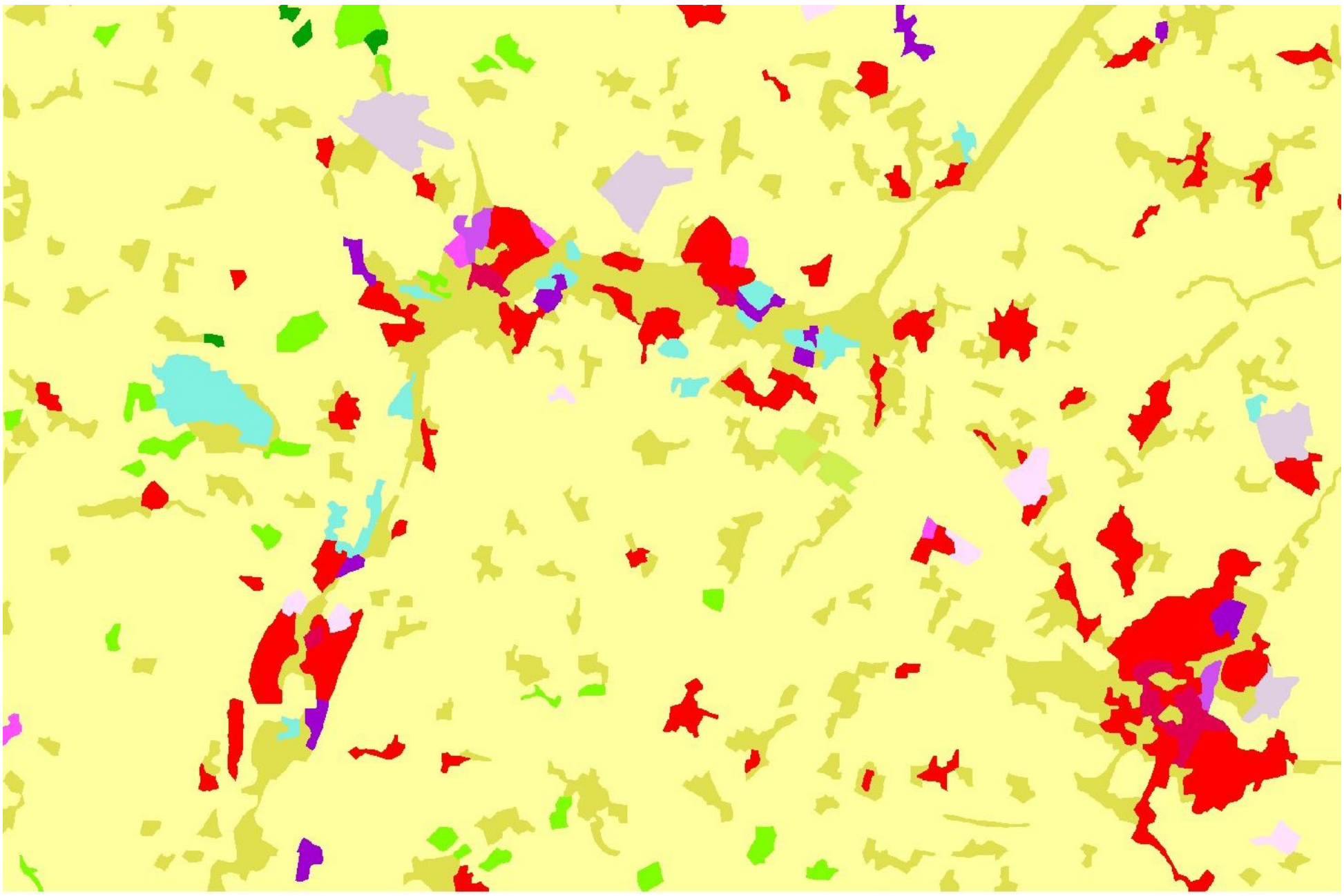


Figure 10. Scatter plot showing the number of pixels/1000 (log scale) identified for each CORINE class by the manual and semi-automated method.

Figure 1. Test site: Arable landscape, Cambridgeshire

(a) CORINE Land Cover from manual interpretation



(b) CORINE Land Cover from semi-automated generalisation

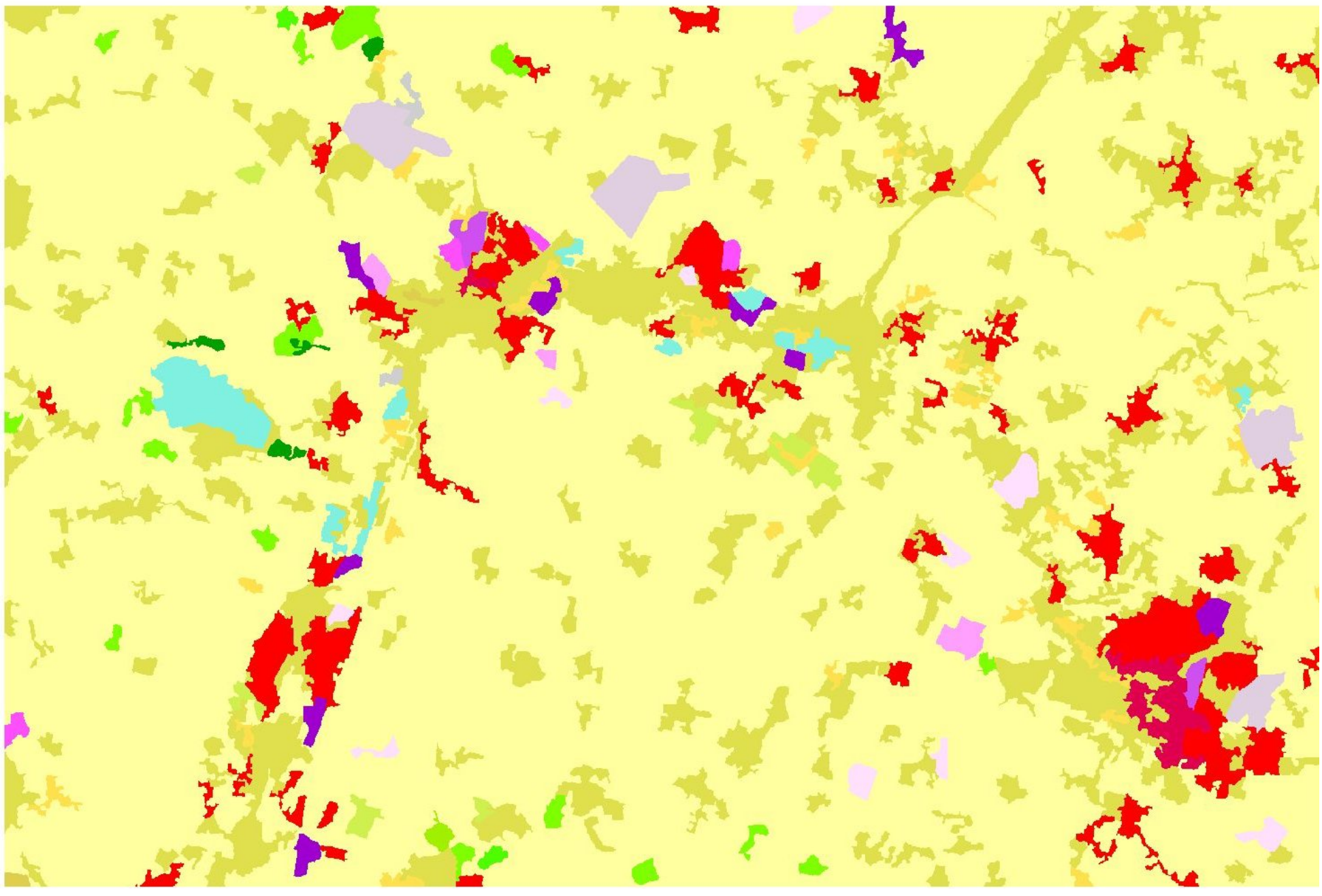


Figure 2. TM imagery with manual interpretation outlines

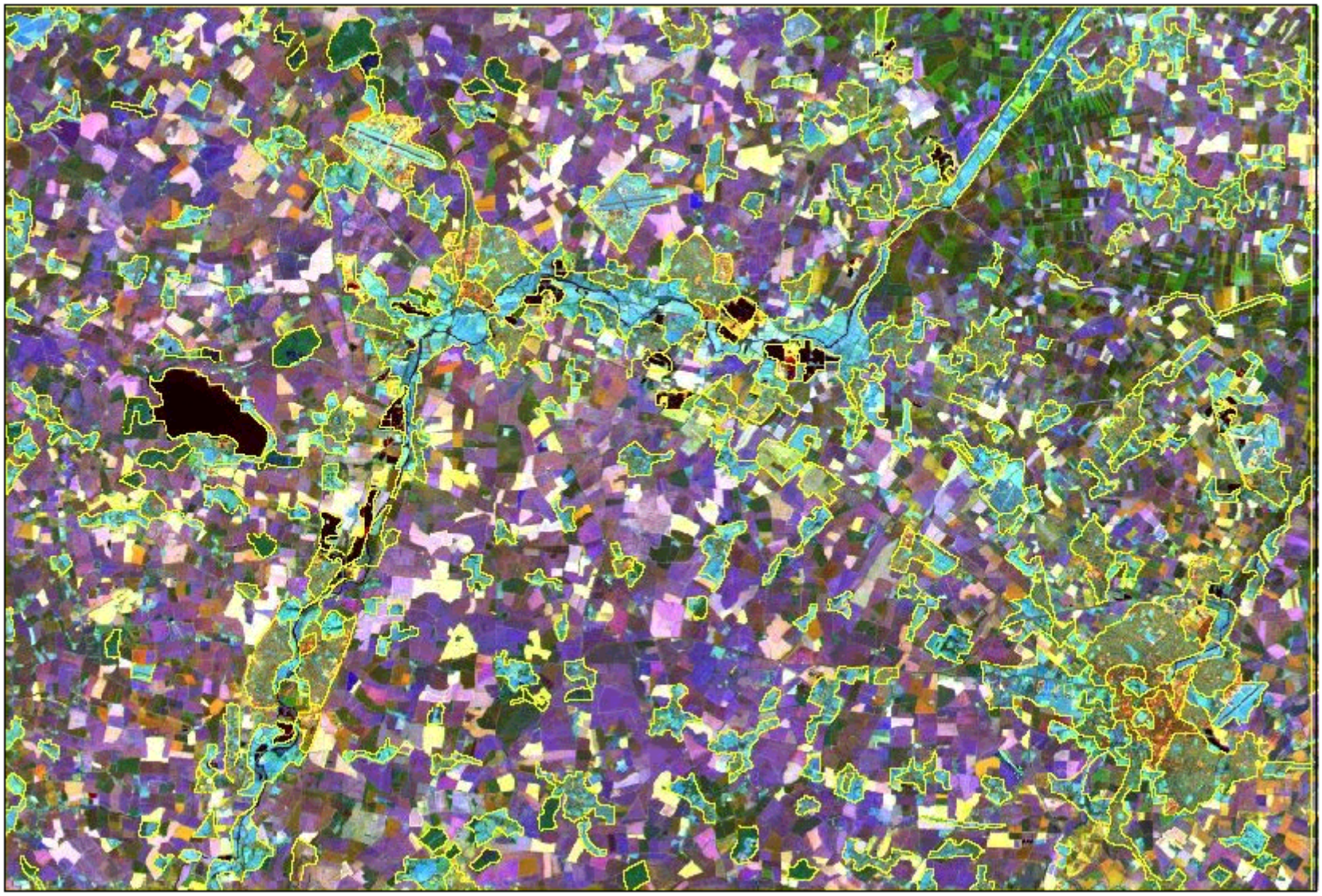


Figure 3. Automated CORINE with manual interpretation outlines

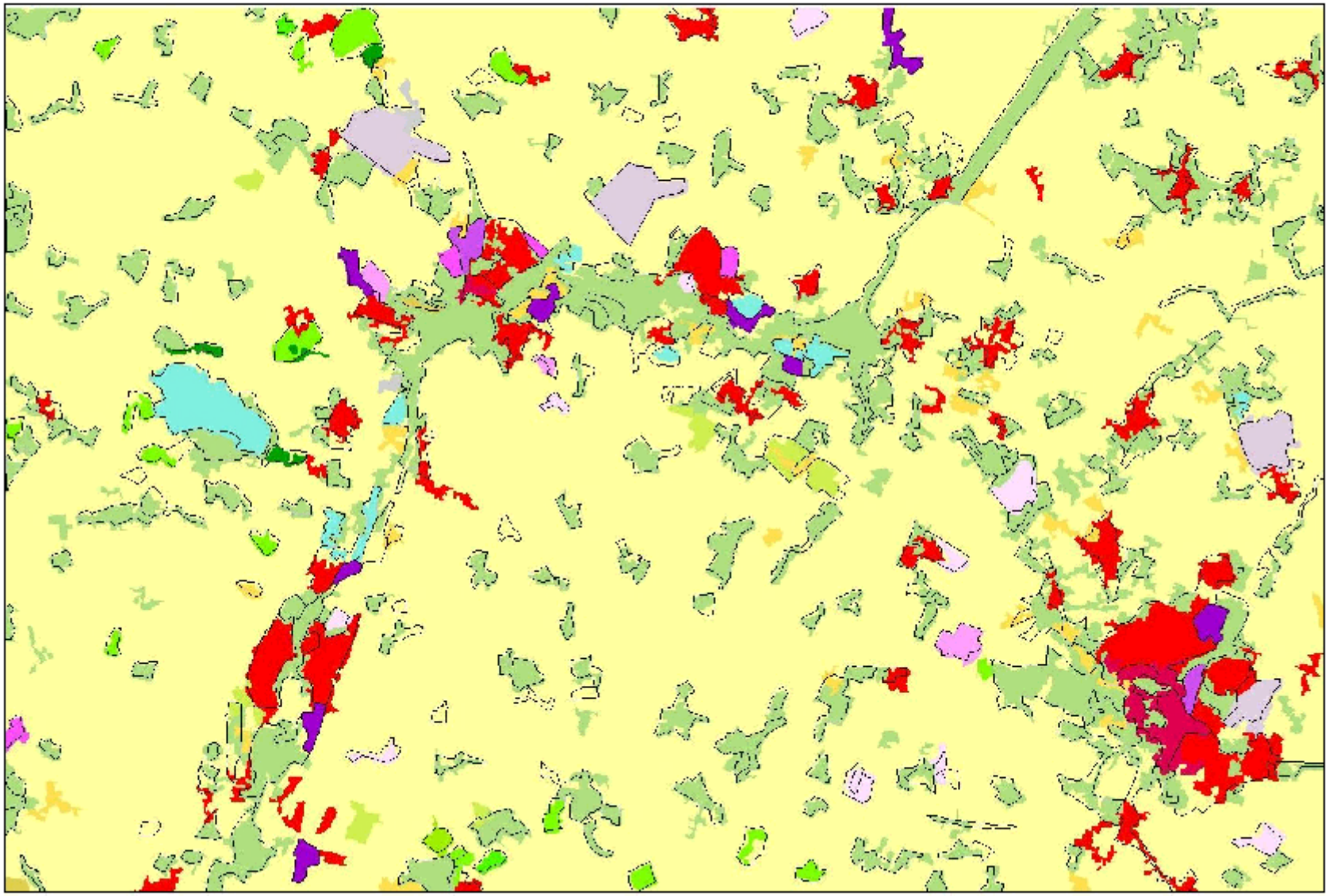
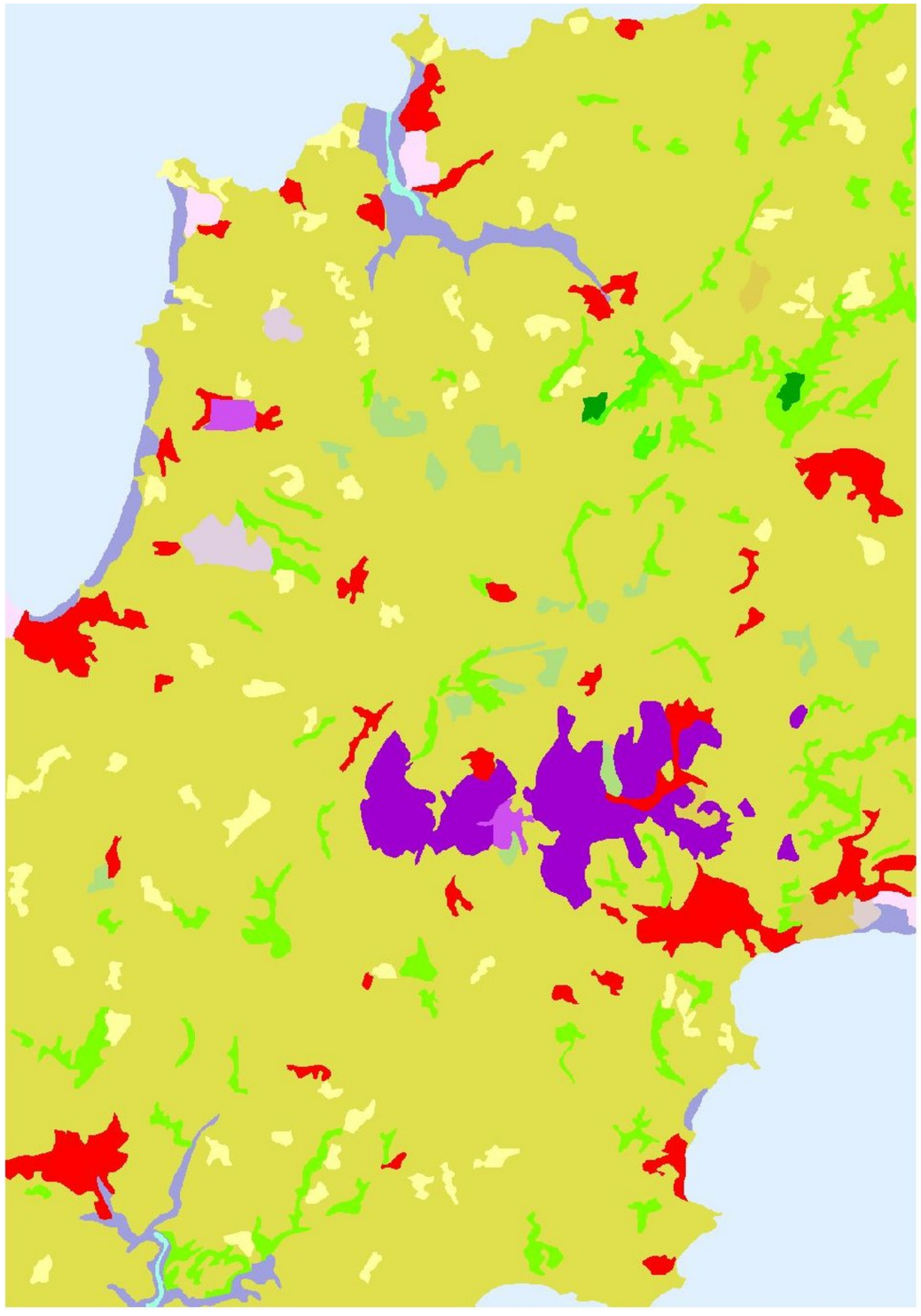


Figure 4. Test site: Pastural landscape , Devon

(a) CORINE Land Cover from manual interpretation



(b) CORINE Land Cover from semi-automated generalisation

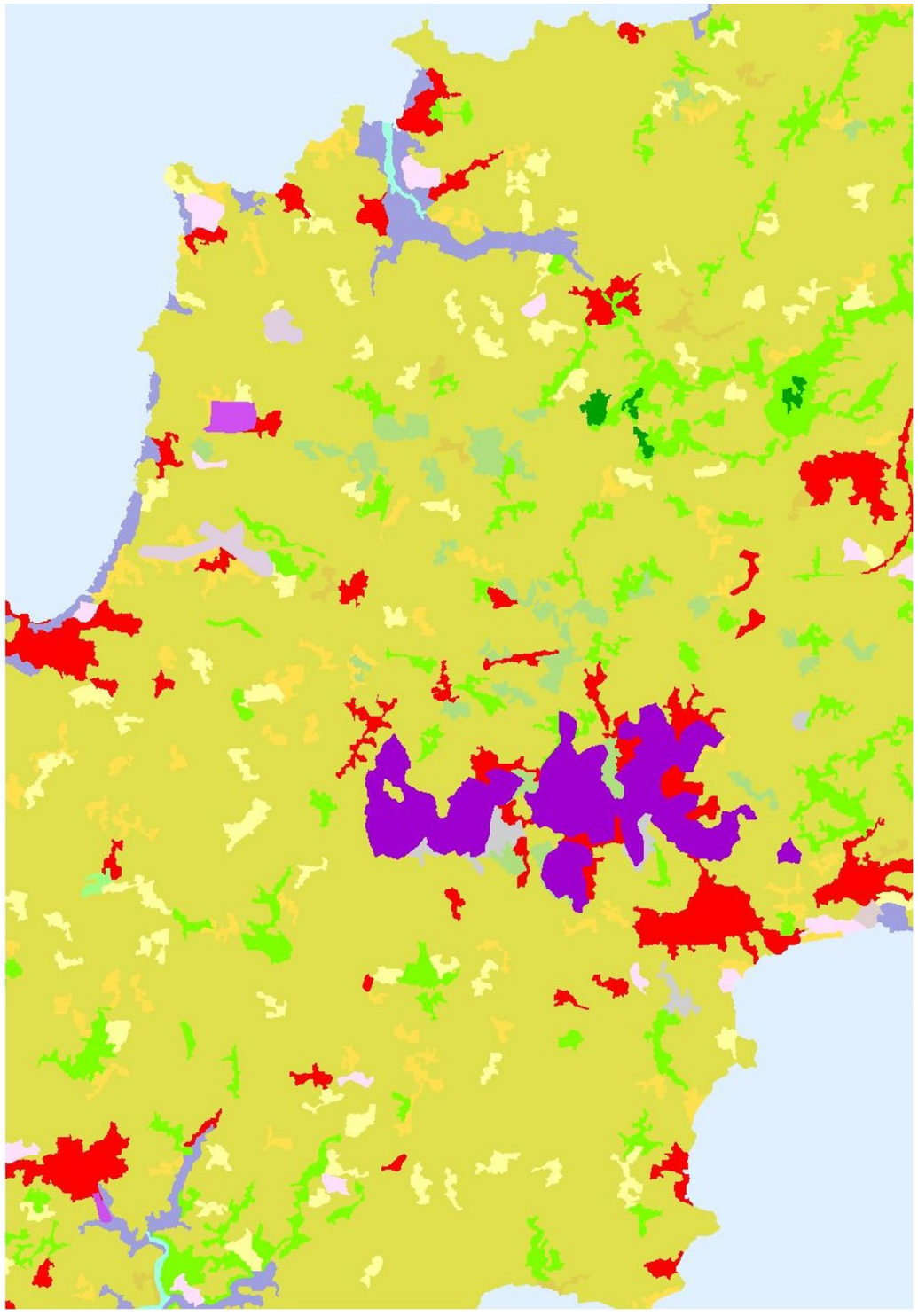


Figure 5. Test site: Marginal landscape, west Scotland

(a) CORINE Land Cover from manual interpretation

(b) CORINE Land Cover from semi-automated generalisation

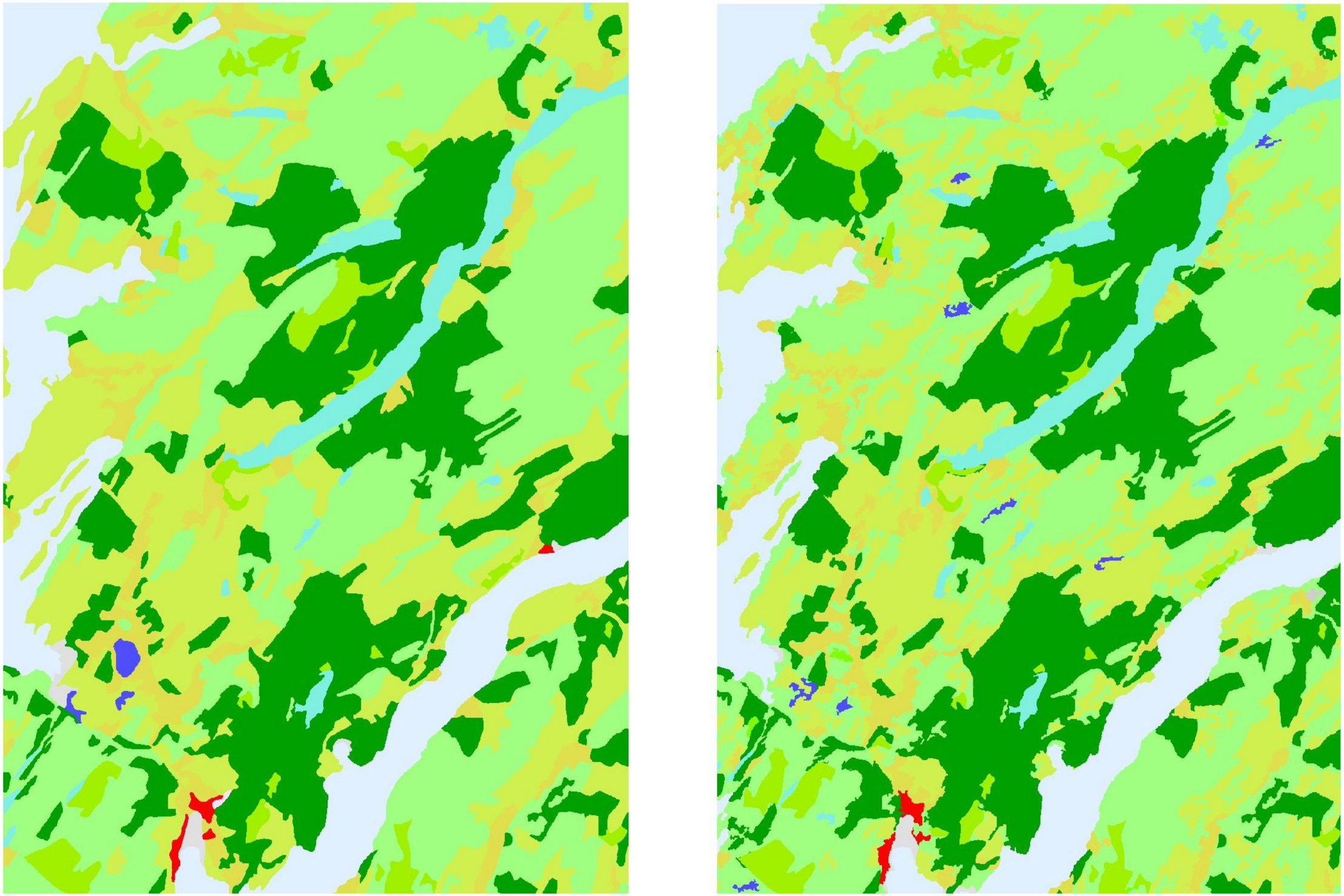


Figure 6. Test site: Marginal landscape, Wales

(a) CORINE Land Cover from manual interpretation

(b) CORINE Land Cover from semi-automated generalisation

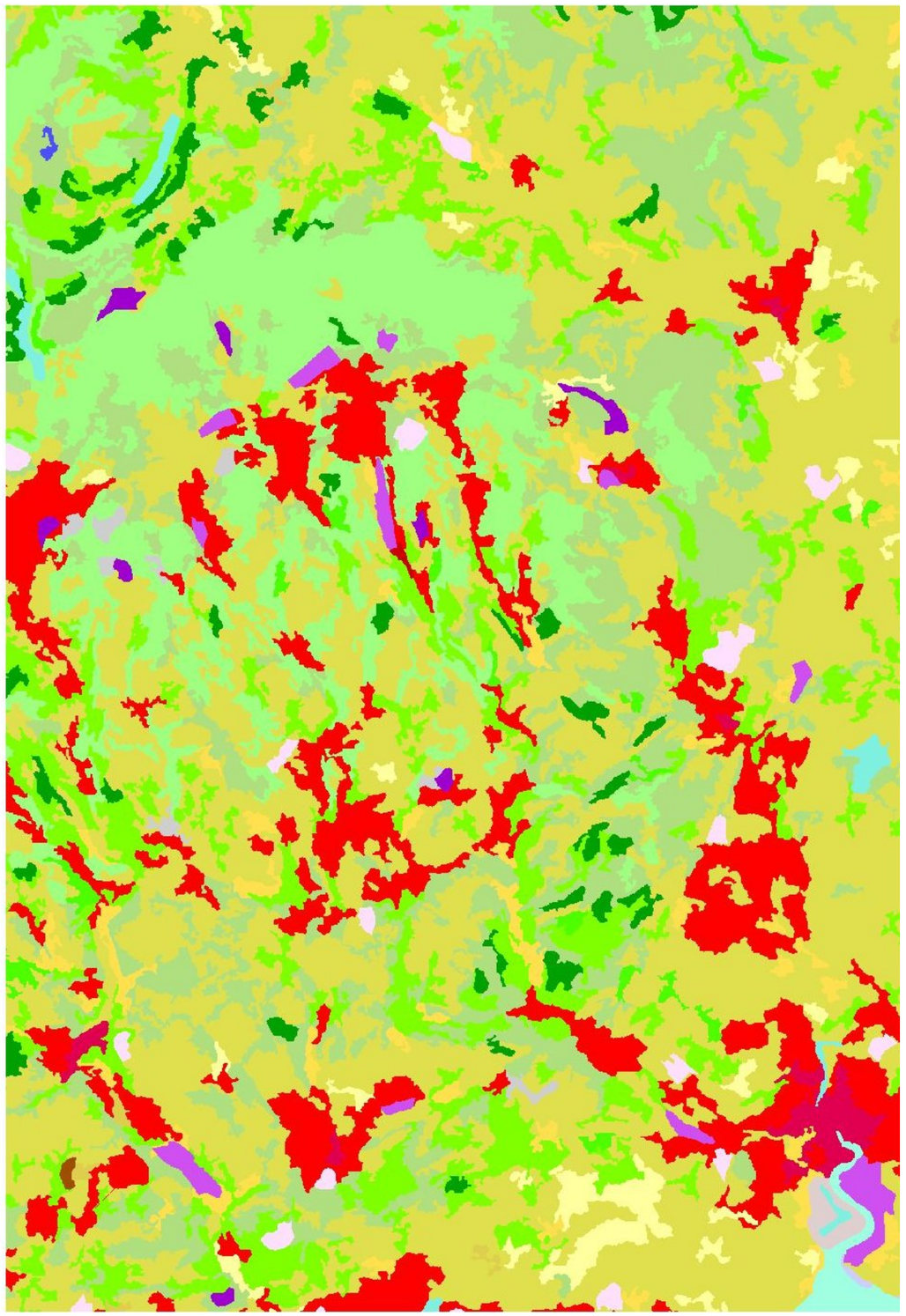
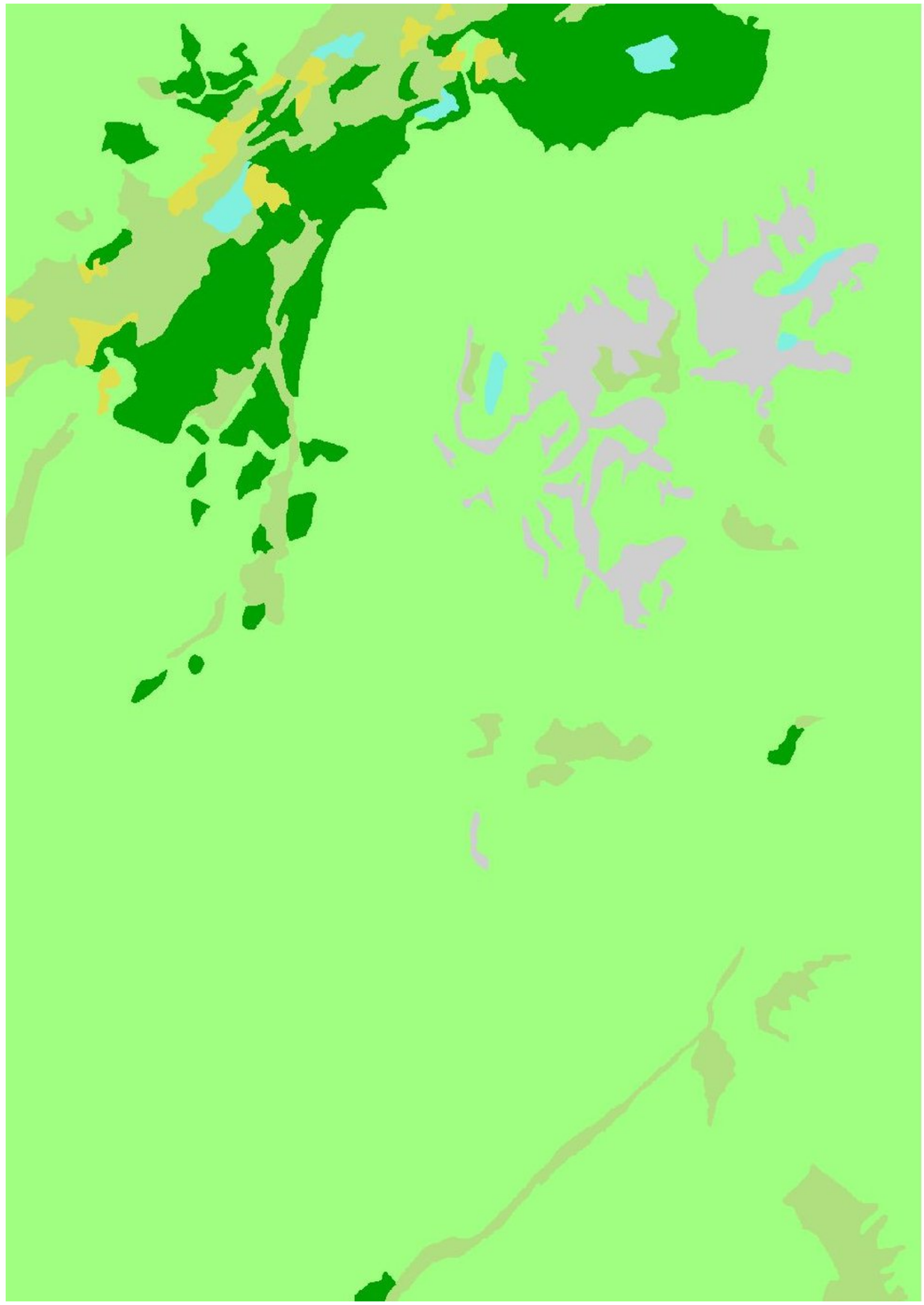


Figure 7. Test site: Upland landscape, east Scotland

(a) CORINE Land Cover from manual interpretation



(b) CORINE Land Cover from semi-automated generalisation

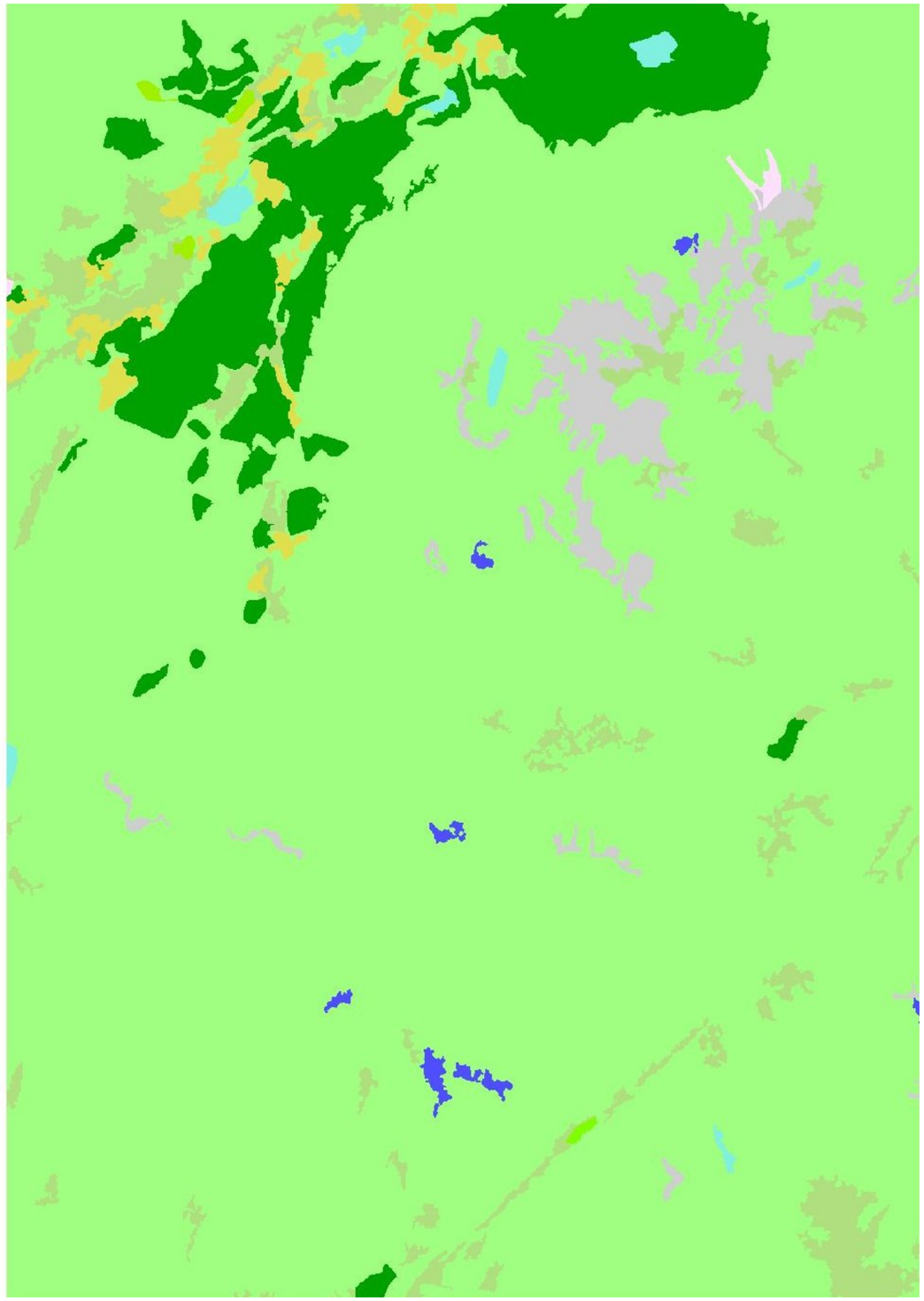


Figure 8. The main landscape types found in the Welsh test site

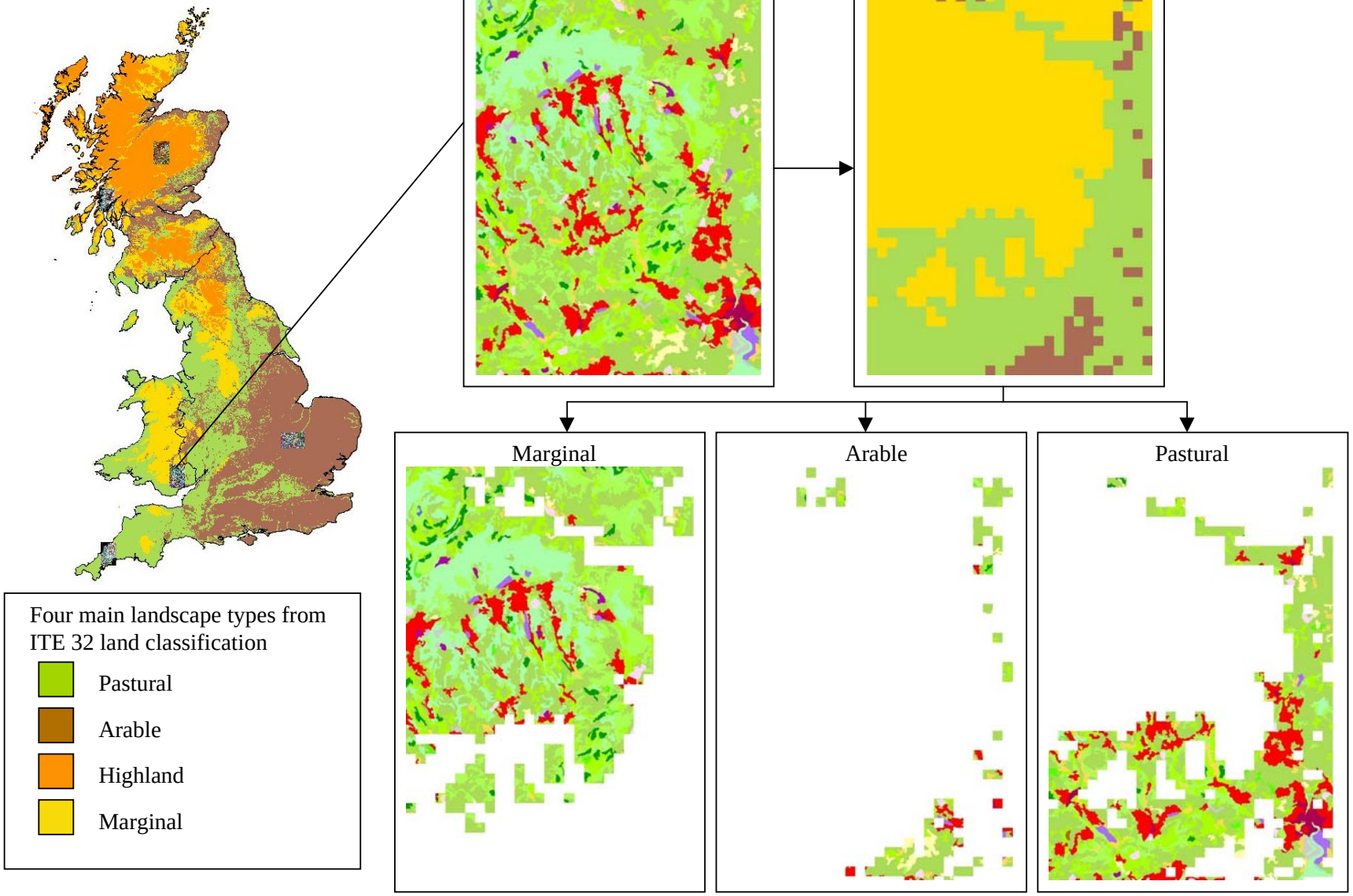


Figure 9

Identifying the pixels from the five test-sites which represent pastoral landscape using the ITE 32 land classification